distinction between cytoplasmic and nuclear maturation; he reared a merogonic sea-urchin larva whose cells had the normal number (18) of chromosomes, although the spermatozoon-nucleus (the only one in this case) imported (it is presumed) but half that number. The last fact leads him to conclude that the number of chromosomes is a specific property of the cell.

Although Delage's experiments stand at present alone as regards the method pursued, there have been of late a number of experimental studies on fertilisation, all of which present points of great interest. From among these we select those of Prof. Jacques Loeb,[1] as it seems of particular importance that his results should be collated with those of Delage.

Loeb finds that the mixture of about 50 per cent. of $\frac{10}{8}$ *n* $MgCl_2$ with about 50 per cent. of sea-water is able to bring about (in the eggs of the sea-urchin *Arbacia*) the same result as the entrance of a spermatozoon. After being subjected to this mixture for about two hours, the eggs were returned to normal sea-water, wherein many developed, forming blastulæ, gastrulæ and plutei. Fewer eggs developed than in natural conditions, and the development was slow, but otherwise the results were normal. The author believes that the only reason why the eggs of this sea-urchin and of other marine animals do not usually develop parthenogenetically is the presence or absence of ions of sodium, calcium, potassium and magnesium. The two former require to be reduced, the two latter to be increased.

"*The unfertilised egg of the sea-urchin contains all the essential elements for the production of a perfect pluteus.*" All the spermatozoon *needs* to carry into the egg for the process of fertilisation are ions to supplement the lack of favourable ions, or to counteract the effects of the other class of ions in the sea-water, or both. "The spermatozoon *may*, however, carry in addition a number of enzymes or other material. But *the ions and not the nucleins in the spermatozoon are essential to the process of fertilisation.*"

It is interesting to observe that while Delage's experiments go to show that the nucleus of the sea-urchin ovum is not essential to development, Loeb's experiments go to show that the spermatozoon may (with intact ova) be dispensed with. What is now needed is a combination of the two modes of experiment.

J. A. T.

CHANGES OF COLOUR OF PRAWNS.

It has long been known that the very numerous varieties of the prawn *Hippolyte* (*Virbius*) *varians* reflect, each after its kind, the colour of the weed or zoophyte to which they cling, and on which they find both food and shelter. A few naturalists, after noting this striking case of "protective resemblance," have detached some of the more brilliantly coloured specimens for the purpose of making a detailed subsequent examination. When they came to do this they found that the vivid brown and other tints had in the interval largely faded, or were replaced by others. This discovery has no doubt been made independently time after time, and has given point and emphasis to the essentially variable character of this prawn. Not only do individuals differ from each other, but any one of them is capable of altering its characteristic tint.

Thus, at the time when Keeble and Gamble began their observations,[2] *Hippolyte varians* was known to change colour, but while one author stated that a sympathetic colour-change was rapidly effected, as well in the dark as in the light, when weed of a new tint was introduced; another affirmed that even in the light the change was slow and did not always agree with the colour of the new weed. Yet a third author stated that darkness by itself has a distinct reddening effect. The only definite conclusion to be drawn from these curiously conflicting statements was that *Hippolyte* offered a fine field for research, and that though a few strollers had here and there plucked an ear or two of corn, there was a fine harvest still to be gathered.

After two years' work on the coasts of Lancashire and of Normandy, Keeble and Gamble have come to the conclusion that three kinds of colour-change may be distinguished in *Hippolyte*.

[1] On the nature of the process of fertilisation and the artificial production of normal larvæ (plutei) from the unfertilised eggs of the sea-urchin. (*Amer. Journ. Physiol.* iii. (1899), pp. 135-138.)

[2] "The Colour-Physiology of *Hippolyte varians*." By F. W. Keeble, Caius College, Cambridge, and F. W. Gamble, Owens College, Manchester. Read before the Royal Society on November 23, 1899.

I. First, a periodic and rhythmic cycle of change composed of a diurnal and a nocturnal phase of colour. Towards evening a decided red tinge—a sunset glow—makes its appearance, and this ushers in the nocturnal change. A green tinge ensues, which spreads fore and aft from the middle of the body. Presently this green colour gives place to an azure-blue colour, which is the characteristic nocturnal tint, and is accompanied by a greatly heightened transparency in the tissues. Under natural conditions this colour-phase persists until daybreak. At the first touch of dawn it disappears, and that of the previous day is gradually reassumed.

More striking even than the distinctive colours is the periodicity of the nocturnal and diurnal phases. Thus, in constant darkness a nocturne (that is a prawn in the nocturnal colour-phase) recovers to its diurnal colour. In constant light, a diurnal form passes over to the nightly phase. Though light often induces, and induces with marvellous rapidity, a recovery from the nocturnal colour to that of the previous day, yet it is often powerless to overcome the habit of the animal. The periodicity is only worn down in the course of two or three days.

It follows that since the colour of *Hippolyte* is a function of the time of day, that time must be taken into account in an investigation on the colours of Crustacea.

II. The second kind of colour-change is the susceptibility of *Hippolyte* to changes of light-intensity. Although the periodic habit of the prawn is the hitherto unknown and yet dominant factor, yet its force is greatest at the times of the assumption of the nocturnal phase, and the resumption of the diurnal tint. At other times external conditions may modify the colour of the animal to a large extent, and the chief agent in the production of these modified colours is the varying amount of light reflected from or scattered by, surrounding objects.

An almost black prawn changed in a few minutes, after being placed in a white porcelain, to a transparent and colourless condition. Further, a ready and almost infallible means of producing green prawns is to place them just after their capture in a white jar, and cover the mouth of the vessel with muslin. Under these circumstances the change—from brown to green, for example—takes place in from thirty seconds to one minute.

Speaking generally, exposure to a low light-intensity during the day favours an expansion of the red pigment, and so produces brown or even reddish effects. Hence, probably the red colour of these prawns at sunset; while an increase in the amount of light, especially if scattered from a white smooth surface, produces a green effect by expanding the blue and yellow pigment and causing the red to contract.

III. The third change differs chiefly from the second in its rate of progress. It is the very slow sympathetic colour-change which ensues when adult prawns, taken from a food-plant of one colour, are placed with the weed of a new colour. Thus, if green *Hippolyte* be placed with brown weed, and the light-intensity maintained unaltered, as far as possible in comparison with the light-conditions of its former habitat, the prawns will retain their green colour even for a week or more, but in the end give way and become brown. Their subsequent recovery when placed with green weed is more rapid. Keeble and Gamble have repeated such experiments time after time in the open, and under as natural conditions as possible, and found that the prawns were either quite refractory or responded in this slow manner. Yet these same specimens, as each evening drew on, underwent the colour-changes culminating in the nocturnal hue with the greatest readiness, and recovered as quickly the next morning to the tint of the previous day.

The great difficulty in ascertaining whether *Hippolyte* responds to change in the colour of its surroundings by a sympathetic change of its own bodily tints is now clear. It lies in their marvellous sensitiveness to changes of light-intensity, as apart from colour, and is increased by the dominant and periodic colour-changes which subvene night and morning. If it were possible to eliminate these two factors, then we might be able to detect the response of *Hippolyte* to colour or change of colour *per se*; in fact, Keeble and Gamble have made an attempt. By the use of colour-screens, based on the instruments used by Landolt and other workers, the prawns are subjected to red, green and blue light, and also a width of a spectrum from the red to the green. The results of these experiments are curious. They show that even when the light transmitted by the screen, and falling on the prawns, is high (the incandescent lamp and a mirror being used to effect this), yet that with red, green and

blue light the colour of the animal becomes more or less rapidly of the nocturnal tint, and the tissues acquire the characteristic transparency. Further, that if these screens be employed all night the prawns do not recover so soon the next morning as do those which are simultaneously exposed to the same source of light in open white dishes. Without attempting to fully explain this effect of monochromatic light, Keeble and Gamble conclude that the prawns do not respond to light of any colour in virtue of its specific wave-length, and that in so far a colour-sense cannot be demonstrated.

Other experiments, however, show that under natural conditions *Hippolyte varians* has the power of choosing from a mixed quantity of weed that one on which it naturally occurs, and with which it agrees in colour. This power of choice is, however, very erratically exhibited. Nevertheless, it would appear to be the chief means of safety should the prawn be violently washed away from its usual habitat.

The colour-changes in *Hippolyte* are largely, if not entirely, controlled by the nervous system. That the eyes are not essential to the daily rhythmic colour-cycle is shown by the fact that blinded prawns nocturne and recover as completely as normal ones, but more slowly and somewhat more erratically. The periodicity does not reside in the eyes and optic ganglia. It is a function of the rest of the nervous system. That the eye is a most important auxiliary in modifying the control of the central system cannot be doubted; but it cannot be supposed that the light, acting through the eye, differentiates such stimuli as to cause each colour-variety to show, as in a mirror, the pattern of its weed. There must be local control, and this, under the strong central organisation, seems to be the efficient force.

The paper closes by a note on the response of the chromatophores of the *zoea*-larva of *Hippolyte*. These colour-elements develop before the time of hatching, and occur, chiefly in pairs, symmetrically throughout the body. Changes of light-intensity, such as alternately placing the larvæ on a black and then a white ground, are rapidly followed by changes in the pigments. In the former case, the yellow-green pigment expands; in the latter, it contracts and the red pigment spreads out. So far as the observations went, these larvæ did not exhibit a blue nocturnal colour phase, and further investigation, upon which the authors are engaged, will have to decide at what period in the life-history periodicity sets in; whether there is a particular phase in development during which the young prawn is specially sensitive to the colour of its surroundings; and if at that time its diurnal colour becomes relatively fixed, as the animal grows into these surroundings.

NATURE STUDY IN RURAL SCHOOLS.

EVERYONE who is familiar with the work of our Education Department knows that the Inspectors are given explicit instructions to discountenance the unintelligent teaching of science, and to do everything in their power to encourage the observation and study of natural objects and phenomena. The "object lessons," which are given in the lower standards, are intended to lead the pupils to use their eyes and compare one thing with another; and though they have become in some schools of too detailed a character to develop the faculties of observation and reasoning, the fault is chiefly due to the fact that many teachers are not observers of nature themselves, and are therefore unable to describe natural things except in the language of the text-book. Every effort has, however, been made by the Education Department to show teachers that this is not the kind of teaching intended to be given as object lessons. Several circulars have been issued containing instructions as to what should be done, and the new Board of Education has shown sympathy with the work of arousing interest in nature by issuing a circular, from which the following extracts have been taken, to managers and teachers of rural elementary schools. The issue of this document by Sir G. W. Kekewich at the very commencement of the work of the Board of which he is the secretary, may, we trust, be taken as an indication that increased attention is to be given to the teaching of scientific subjects in elementary schools:—

The Board would deprecate the idea of giving in rural elementary schools any professional training in practical agriculture, but they think that teachers should lose no opportunity of giving their scholars an intelligent knowledge of the surroundings of ordinary rural life and of showing them how to observe the processes of nature for themselves. One of the main objects of the teacher should be to develop in every boy and girl that habit of inquiry and research so natural to children; they should be encouraged to ask their own questions about the simple phenomena of nature which they see around them, and themselves to search for flowers, plants, insects, and other objects to illustrate the lessons which they have learnt with their teacher.

The Board consider it, moreover, highly desirable that the natural activities of children should be turned to useful account—that their eyes, for example, should be trained to recognise plants and insects that are useful or injurious (as the case may be) to the agriculturist, that their hands should be trained to some of the practical dexterities of rural life, and not merely to the use of pen and pencil, and that they should be taught, when circumstances permit, how to handle the simpler tools that are used in the garden or on the farm, before their school life over.

The Board are of opinion that one valuable means of evoking interest in country life is to select for the object-lessons of the lower standards subjects that have a connection with the daily surroundings of the children, and that these lessons should lay the foundation of a somewhat more comprehensive teaching of a similar kind in the upper standards. But these object-lessons must not be, as is too often the case, mere repetitions of descriptions from text-books, nor a mechanical interchange of set questions and answers between teacher and class. To be of any real use in stimulating the intelligence, the object-lessons should be the practising ground for observation and inference, and they should be constantly illustrated by simple experiments and practical work in which the children can take part, and which they can repeat for themselves at home with their own hands. Specimens of such courses can be obtained on application to the Board of Education. These may be varied indefinitely to suit the needs of particular districts. They are meant to be typical and suggestive, and teachers, it is hoped, will frame others at their discretion. Further, these lessons are enhanced in value if they are connected with other subjects of study. The object-lesson, for example, and the drawing lesson may often be associated together, and the children should be taught to draw actual objects of graduated difficulty, and not merely to work from copies. In this way, they will gain a much more real knowledge of common implements, fruits, leaves, and insects than if these had been merely described by the teacher or read about in a lesson-book. Composition exercises may also be given—after the practical experiments and observations have been made—for the purpose of training the children to express in words both what they have seen and the inferences which they draw from what they have seen; and the children should be frequently required and helped to describe in their exercise books sights of familiar occurrence in the woods and in the fields. Problems in arithmetic connected with rural life may also be frequently set with advantage.

The Board of Education also attach considerable importance to the work being done by the elder scholars outside the school walls, whether such work takes the form of elementary mensuration, of making sketch plans of the playground and the district surrounding the school, of drawing common objects, ponds, farms, and other suitable places under the guidance of the teacher, or of the cultivation of a school garden.

The teacher should as occasion offers take the children out of doors for school walks at the various seasons of the year, and give simple lessons on the spot about animals in the fields and farmyards, about ploughing and sowing, about fruit trees and forest trees, about birds, insects and flowers, and other objects of interest. The lessons thus learnt out of doors can be afterwards carried forward in the schoolroom by reading, composition, pictures, and drawing.

In this way, and in various other ways that teachers will discover for themselves, children who are brought up in village schools will learn to understand what they see about them, and to take an intelligent interest in the various processes of nature. This sort of teaching will, it is hoped, directly tend to foster in the children a genuine love for the country and for country pursuits.

It is confidently expected that the child's intelligence will be so quickened by the kind of training that is here suggested that he will be able to master, with far greater ease than before, the ordinary subjects of the school curriculum.